InfiNet Wireless Solutions for Video Surveillance

Application notes

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Abstract

The utility and wide spread of surveillance cameras in today's world are obvious facts. Whether they are used for security reasons in banks and other public institutions, for medical, industrial, military, traffic monitoring, city surveillance, border patrol or private use, surveillance systems are capable, with today's advanced technology to offer very detailed images. The video surveillance market continues to denote a sustainable growth in every segment from commercial to defense, aviation, maritime security, etc.

Introduction

The scope of the current paper is to show the performance of InfiNet equipment when used for PTZ cameras connectivity. The lab setup scenario is thought to simulate a real deployment of a common video surveillance scenario (generating multi UDP megabit streams at different rates) in order to emphasize by the output results that an InfiNet BS sector can support a large number of PTZ cameras with high quality transmissions (no bandwidth limitations or latency issues).

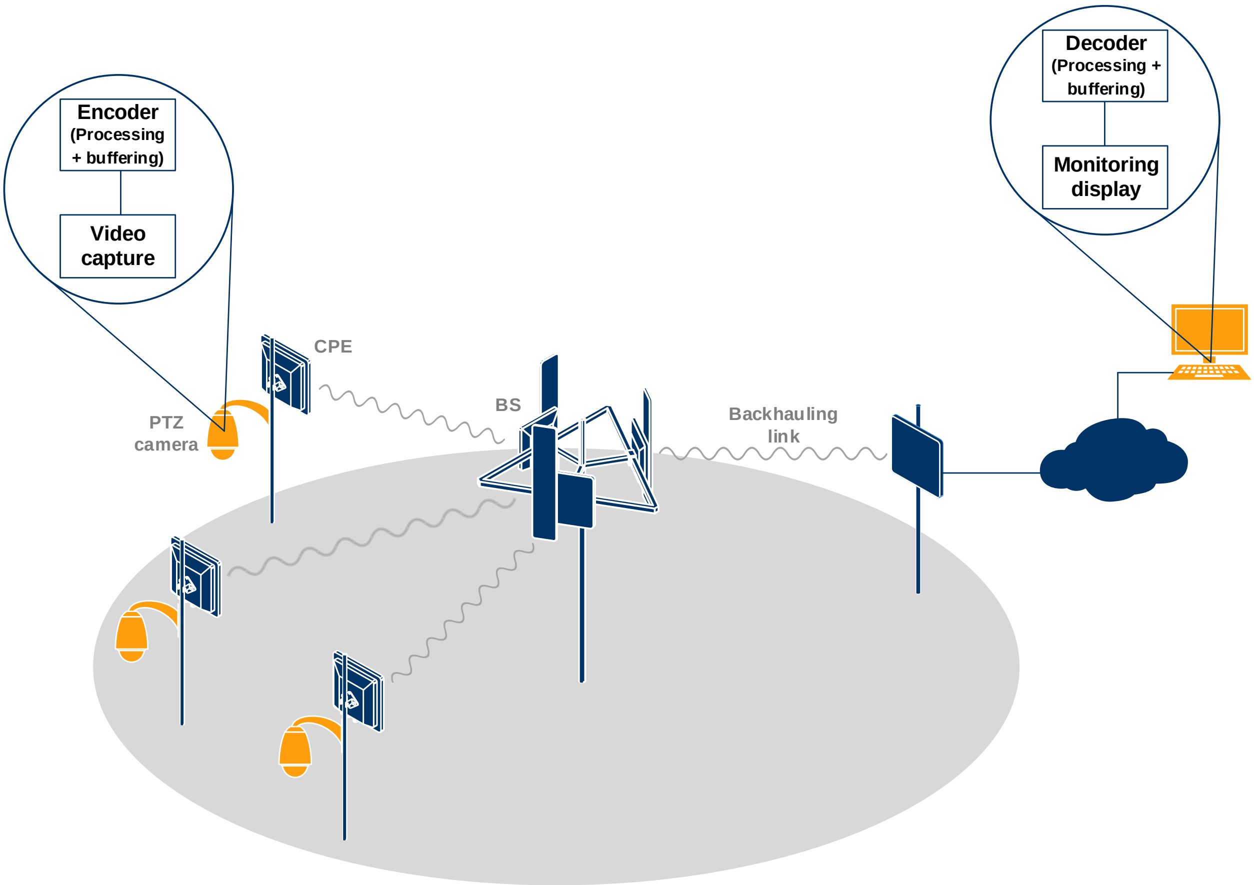

Figure 1 - General video surveillance wireless network architecture

Theoretical grounds

PTZ camera characteristics

PTZ cameras are defined by the implementation of the pan/tilt/zoom functions in order to deliver detailed video images by focusing on specific zones, in real time. They are suitable for wide areas of applications and provide a very good flexibility. Important considerations about PTZ cameras:

- Real-time interaction - PTZ cameras are used not only for storage or passive monitoring, but they require real-time interaction in response to the captured images.
- Latency - PTZ cameras have very low latency demands compared to other types of video cameras. In order to be able to react efficiently, the captured frame has to be accurately time correlated with the displayed image at the monitoring station or with the server issuing the commands in case of automatic control. The delay from the camera through the network to the monitoring station has to be minimized as much as possible.
- Resolution - PTZ cameras usually require a high resolution; the most performant cameras can offer up to 2592x1944 pixels resolution (e.g. for face recognition and car plate recognition).
- Compression - PTZ cameras usually implement M-JPEG or H.264 video codecs which offer good compression rate for high resolution images.
- Bandwidth - high resolution motion pictures require higher bit rates and in consequence more and guaranteed bandwidth must be provided by the network components.

PTZ system latency

PTZ system latency represent the time passed between an actual commands sent to the camera (pan/tilt/zoom) and the moment its effect takes place. Bear in mind that each equipment along the way introduces its own processing delay and each network segment (referred as the transmission medium) introduces a propagation delay, too.

There’s not an absolute value required for the PTZ system latency parameter, as each application has its own requirements. For instance, in order to be one step ahead the human eye perception, a good system latency of a video stream is considered at maximum 200 ms. For a video-conference, tighter constraints come from correlating the voice with the images and this lowers the acceptable latency to maximum 100 ms. In case of real time interaction with the PTZ cameras, the required limit would be at maximum 30 ms, etc.

Network traffic demands

Both the PTZ cameras and the network devices should support multicast and uplink optimization: when multiple people receive the same video stream sent by a particular PTZ camera, for an efficient data traffic in the network, the stream must be sent as multicast. Multicast sends one stream to multiple monitoring stations unlike unicast which sends one video stream per each monitoring station.

Usually PTZ cameras enable streaming at constant bit rates (CBR) in order to prevent bandwidth overutilization when higher data is needed to be sent for the accuracy of some video frames (assuming the reduced video quality in the corresponding moments). But, in order to avoid this situation, PTZ cameras can enable also streaming at variable bit rates (VBR) which leads to more bandwidth demands during high detail/ fast motion recording, so the network infrastructure should be able to support these spikes of video traffic. Usually VBR is the preferred method for PTZ cameras that require high image quality, but this will add delay at the encoder side, compared to CBR because of the variable bit rate.

Encoders overview

Encoders offer specialized compression technologies in order to reduce the image sizes while being transferred over the network. The main consideration is the balance between the bandwidth and storage constraints versus maintaining a good image quality.

The following types of codecs are commonly applicable to the video surveillance systems:

- Intra-Frame: JPEG, JPEG2000, M-JPEG - codes a single image on a standalone basis.

For instance, M-JPEG standard breaks the video stream into individual JPEG images, independent of each other. This makes it suitable for high quality image requirements, but it results in inefficient bit rate compared to the other codecs. Although it will consume more bandwidth and storage, in terms of latency it is better than MPEG-4 and H.264.

- Inter-Frame: MPEG-4, H.264 - makes use of the redundancy between nearby video frames and it is based on motion vectors that predict frame content.

MPEG-4 discards the redundant information and performs an efficient compression based on the differences between frames, but works for low resolutions. It is suitable for low bandwidth requirement applications.

H.264 is the latest standard for compression and provides better image quality and error robustness for the same bit rate compared to MPEG-4 and M-JPEG. It is the most efficient in terms of bandwidth usage, storage demands and image quality, making it a very suitable candidate for real time video surveillance applications. It is also designed to offer lower latency or better quality for the higher latency values.

Bitrate demands

Depending on the resolution used, frame rate, video complexity (static or in motion) and compression method (codec type), minimum bit rates are necessary to sustain the desired image quality:

Resolution	Compression	Frame rate (fps)	Bitrate (Mbps)
352x288 (2CIF)	MPEG-4	15	0.2 ~0.4
352x288 (2CIF)	MPEG-4	30	0.4 ~1.5
704x576 (4CIF)	MPEG-4	15	0.8 ~1.0
704x576 (4CIF)	MPEG-4	30	2.0
1280x1024	H.264	5	0.7

1280x1024	M-JPEG	5	4.5
1600x1200	H.264	5	1.0
1600x1200	M-JPEG	5	6.0
2048x1200	H.264	5	1.5
2048x1200	M-JPEG	5	9.5
960x450 (540p)	H.264	30	0.8~1.5
1280x720 (720p)	H.264	30	1.3~4.0
1920x1080 (1080p)	H.264	30	3.0~7.0

Table 1 - Bit rates demands

These values emphasize the conclusions above: MPEG-4 can be used for lower resolutions, M-JPEG offers good image quality but consumes more bandwidth, while H.264 results in lower bit rates but the practical implementations show that it introduces higher latency than M-JPEG.

Why wireless infrastructure for video surveillance?

- Easy installation and maintenance - Setting up a wired network requires cabling and digging and it can be a very complex operation, resulting also in more complex maintenance of the infrastructure
- Quick deployment - because of the cabling process the installation of wired networks will take couple of months while the wireless infrastructure can be ready starting from couple of days to few weeks depending on the size of the project.
- Lower costs - the installation costs are lower for wireless solutions and can go up to 80% less than for a cabling network, depending on the complexity of the project and chosen equipment.
- Flexibility - only using wireless systems it is possible to cover areas where cabling is not accessible. Sometimes cabling isn’t even an option: city centers, parking lots, industrial areas and other places can have infrastructure restrictions.
- Scalability - if it’s decided to move the location of a certain camera, in the case of wireless it is a simple process. Also, if new cameras need to be added in a location it is very easy to setup the physical scenario.

Why InfiNet Wireless?

InfiNet Wireless has a vast experience in the video surveillance market, providing numerous high reliable and secure solutions all over the world. Complete transmission solutions are available for traffic monitoring, ANPR, highway safety, city surveillance and many others.

- Efficient investment: available capacity according to customer needs - InfiNet Wireless Base Stations provide high sector capacity which is field-upgradeable from 40 Mbps to 240Mbps and is designed to use less of the valuable radio spectrum than traditional PtMP wireless systems. InfiNet CPEs are able to cater for bandwidth requirements between 8 Mbps and 50 Mbps net capacity.

- Full support for real time applications - transmission of high quality real time video streams using QoS for traffic prioritization (16 priority levels) in order to ensure the lowest latency and smooth display of the video stream. Even with no QoS settings configured, the system can detect and prioritize, by default, the real time packets and doesn't perform concatenation for such packets.
- Optimization for uplink - special handling of upstream multicast flows in video surveillance systems. Base Station can be configured with the downstream option and CPEs with the upstream option resulting in the multicast traffic at Base Station to be directed from radio to Ethernet and prevent multicast storms. InfiNet solutions are fully optimized to cater for uplink applications, providing high throughputs required for streaming live high-quality video without interruptions.
- Multicast traffic switching - in complex scenarios with multiple Base Stations connected to the same switch, IGMP snooping is the solution to avoid multicast storms. With IGMP multicast learning enabled (IGMP snooping option), users are divided in multicast groups and each group will receive only its relevant packets. This implies also having configured an IGMP Querier which will handle the multicast traffic by blocking and unblocking stream transmission.
- Dynamic TDD - the ratio of the incoming/outgoing flows is dynamically changing in order to allocate bandwidth to the direction which mostly requires it. This is a relevant feature in video surveillance because uplink direction has much higher demands.
- ARQ - error packets can be an issue in video surveillance because it will result in loss of information that might be crucial. ARQ feature will retransmit the error packets and ensure a high quality of the stream transmission, as video surveillance traffic is mainly UDP based.
- Traffic shaping - data streams can be assigned to different logical channels previously configured with certain priorities and transfer rates. In case of traffic bursts which can lead to delay variations, the traffic shaping feature can buffer excessive packets and send them over the physical medium at a constant rate.
- Secure and easy to manage - easy to install, ready to go, efficient management (Web GUI, CLI, SSH, SNMP, NMS), security over the air using advanced 128 bit encryption.
- High reliability - up to 99.9999 % availability, standard temperature range (-40 to +60 °C), extended temperature range (-55 to +60 °C), aluminum enclosed with unique pressure control, dust, water and moisture protection according to standard.
- Flexible frequency range - the common WiFi band of 2.4 GHz is overpopulated. InfiNet equipment can operate in a wide range of frequencies from 3.1 GHz up to 6.4 GHz.

Lab measurements

The lab setup consists in a point-to-multipoint BS sector with 5 CPEs working at different bitrates (not the maximal ones). Latency values were recorded for different traffic loads (adding UDP data streams gradually from the traffic generator).

Multiple UDP streams of 3 Mbps each are sent in parallel for each CPE in order to simulate the video traffic generated by the PTZ cameras. There are 7 scenarios, each raw of the table below representing one of the scenario, each of them with different traffic load injected in the CPEs. The video encoding used for the generated streams is H.264 and the bitrate is constant (CBR).

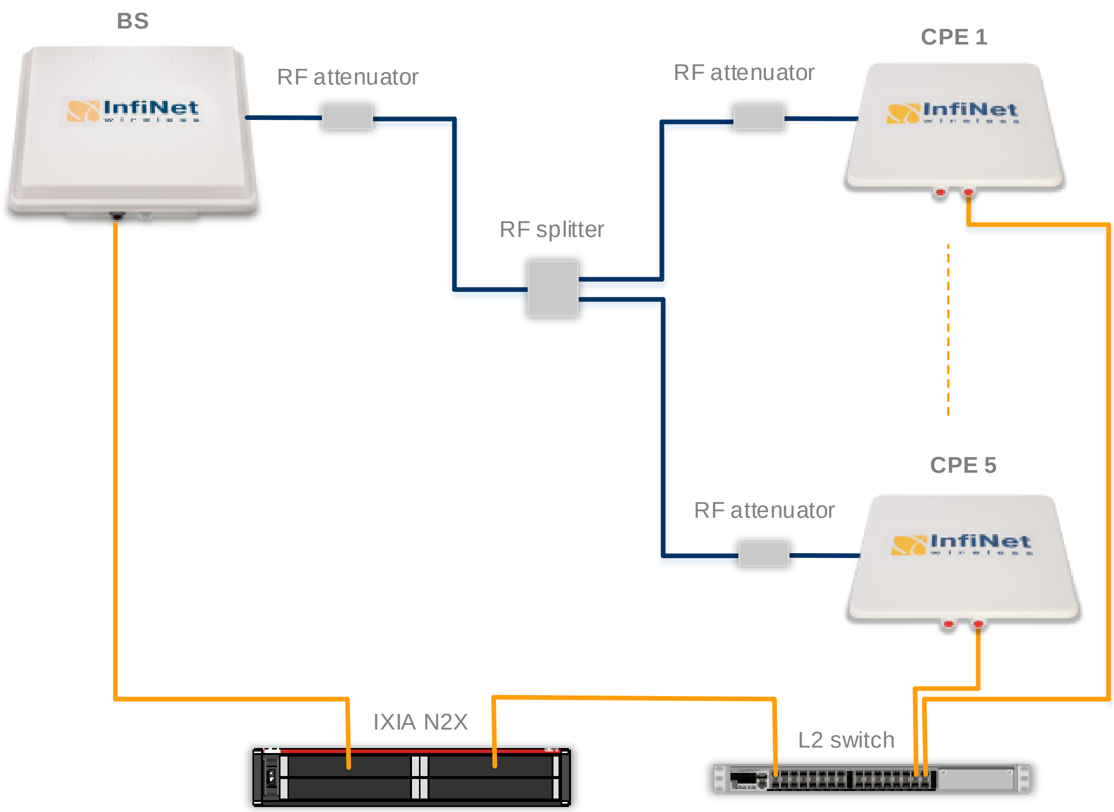

Figure 2 - Test scenario

UDP traffic is generated until packets begin to get lost and the latency is measured for each stream resulting in a range of latency values, as shown in the table below:

CPE 1 (117 bitrate)	CPE 2 (117 bitrate)	CPE 3 (117 bitrate)	CPE 4 (78 bitrate)	CPE 5 (78 bitrate)	PTZ Latency (ms)
5 streams (15 Mbps)	5 streams (15 Mbps)	5 streams (15 Mbps)	4 streams (12 Mbps)	4 streams (12 Mbps)	1.0-1.8
6 streams (18 Mbps)	6 streams (18 Mbps)	5 streams (15 Mbps)	4 streams (12 Mbps)	4 streams (12 Mbps)	1.0-1.8
6 streams (18 Mbps)	6 streams (18 Mbps)	5 streams (15 Mbps)	5 streams (15 Mbps)	4 streams (12 Mbps)	1.2-2.0
6 streams (18 Mbps)	6 streams (18 Mbps)	5 streams (15 Mbps)	5 streams (15 Mbps)	5 streams (15 Mbps)	1.5-2.2
0 streams	0 streams	0 streams	10 streams (30 Mbps)	10 streams (30 Mbps)	1.7-2.5
6 streams (18 Mbps)	6 streams (18 Mbps)	6 streams (18 Mbps)	5 streams (15 Mbps)	5 streams (15 Mbps)	1.8-2.7
11 streams	11 streams	11 streams	0 streams	0 streams	2.0-3.0

(33 Mbps)	(33 Mbps)	(33 Mbps)			

Table 2 - Latency ranges

Although the latency values have a slight increasing trend with the traffic load increase from one scenario to another, they remain very low overall.

The graph below is a visual representation of the values in the table, taking into consideration the maximum latency values for each scenario (each row of the table):

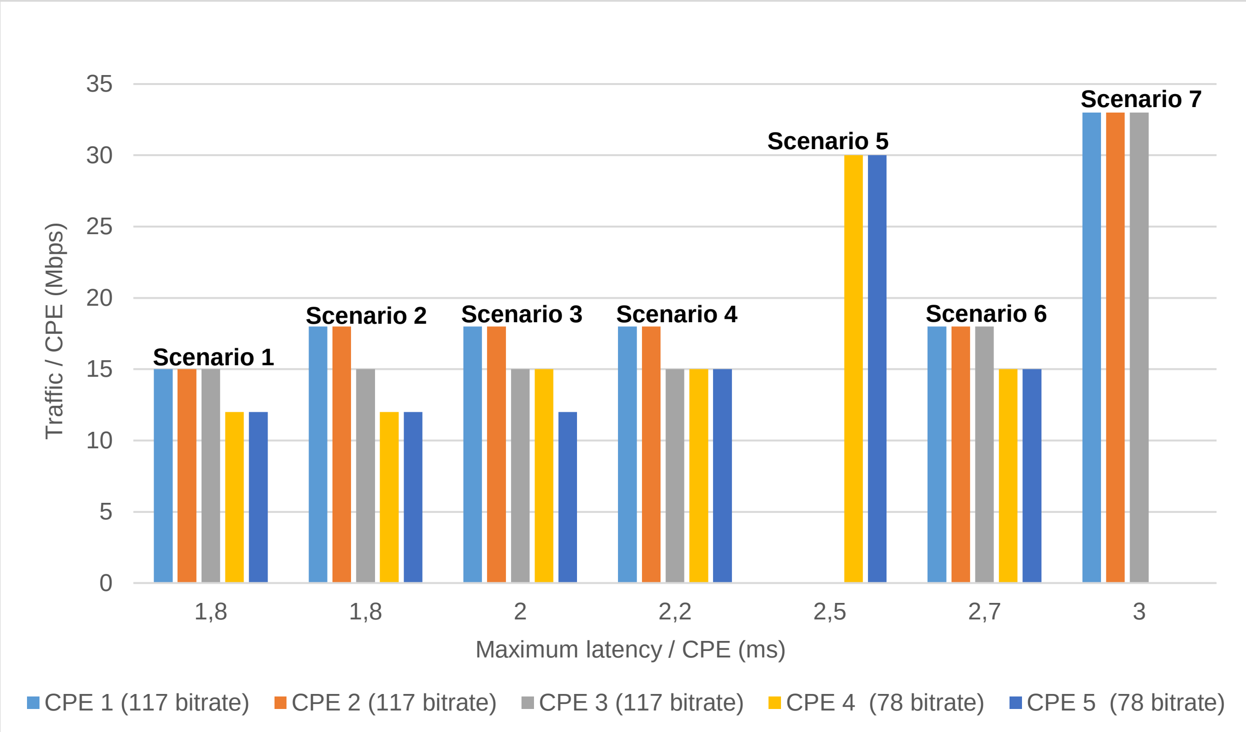

Figure 3 - Latency variation with the traffic growth

Conclusions

The measured results in the above scenarios demonstrate that both the BS and CPEs are capable of handling multiple video streams (up to 33 Mbps per CPE and up to 99 Mbps aggregated traffic at the BS) with very low latency (up to 3 ms).

Also, taking into account the InfiNet Wireless specific features for video surveillance applications and gained benefits, there is a clear conclusion that the transmission solutions using InfiNet Wireless products is a match for any video surveillance application, allowing flexibility for customers in choosing the most proper wireless network equipment from the considerations of cost/performance, the proper PTZ cameras from the market to meet the requested quality and allowing the appropriate codecs and parameters configuration for streaming live high-quality video without interruptions.